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Airline loyalty (programs) across borders: A geographic discontinuity approach



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ABSTRACT

We analyze brand loyalty advantages of national airlines in their domestic countries using geocoded data from a major international frequent flier program. We employ a geographic discontinuity design that estimates discontinuities in program activity at the national borders of the program's sponsoring airlines in the Schengen area of Europe. We document that foreign consumers earn about 60% less miles and are 70% less likely to be a program member. Controlling for self-selection, we also find suggestive evidence for higher purchase frequency and transaction size by domestic members. These results imply that national airlines enjoy a large loyalty advantage in their domestic country, and contribute to an explanation as to why international flights by third country carriers are still a small share of the market.

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1. Introduction

Brand loyalty can be a significant source of competitive advantage, as it implies a reluctance to switch to competing brands by consumers (Klemperer, 1995; Chen and

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Rosenthal, 1996; Farrell and Klemperer, 2007; Dubé et al., 2010). One way in which firms build brand loyalty is through the use of loyalty programs, such as frequent flier programs that proliferate in the airline industry.¹ These programs create incentives for consumers to concentrate their purchases with a single airline and provide airlines market power over their program membership base.

The literature on frequent flier programs focuses on their role in creating competitive advantages for airlines that dominate an airport (see, e.g., Levine, 1987; Banerjee and Summers, 1987; Borenstein, 1996; Lederman, 2007, 2008; Escobari, 2011).² Theoretically, dominant airlines offer the best opportunities to earn and redeem rewards, because they provide the most extensive range of routes. Therefore, local consumers are more likely to become loyal to that airline (e.g., Borenstein, 1996). In two seminal papers, Lederman (2007, 2008) provides empirical evidence of this effect by showing that frequent flier programs have the largest impact on demand and fares on routes from airports at which airlines (and their partners) have a major presence.

The above studies establish how frequent flier programs impact airline competition and market structure in domestic airline industries. These findings are likely more pronounced in the international airline industry, where consumers tend to be biased towards domestic products and services.³ This is particularly important because in most countries, there is one distinct national airline that has a large share of the international market.⁴ Here, in addition to being attractive in terms of earning and redemption possibilities, consumer loyalty towards their national airline may provide that airline with an additional advantage over its foreign competitors.

In the current paper, we analyze the prevalence of national brand loyalty in international aviation markets by estimating discontinuities in frequent flier program activity at the national borders of the program's sponsoring airlines. One of the key features is the use of geocoded microdata on program membership and transactions in a *geographic discontinuity design* that compares program activity by domestic and foreign consumers who reside in close proximity to the border.⁵ As these consumers belong to practically the same geographic region, all unobserved supply and demand characteristics that vary

¹ See Mason and Barker (1996) and de Boer and Gudmundsson (2012) for the history of frequent flier programs.

² We are aware of an extensive literature on the pro- or anti-competitive effects of loyalty programs (see, e.g., Caminal and Matutes, 1990; Kim et al., 2001; Caminal and Claici, 2007; Fong and Liu, 2011). Moreover, some papers examine the moral hazard implications of frequent flier programs more specifically (e.g., Basso et al., 2009). The current paper considers loyalty program activity as a proxy to study spatial variation in brand loyalty and does not take up the debate on the welfare implications of loyalty programs.

³ Numerous behavioral studies show that consumers exhibit a positive bias towards domestic brands (see, e.g., Verlegh and Steenkamp, 1999; Balabanis and Diamantopoulos, 2004; Verlegh, 2007). The potential importance of consumer preferences for domestic brands is also implied by empirical findings from a number of international trade studies in the car industry (Verboven, 1996; Goldberg and Verboven, 2001; Cosar et al., 2016).

⁴ It is also noteworthy that many airlines stress their national brand image. For example, airline brand names often reflect the airline's nationality (e.g., American Airlines, British Airways, Air France).

⁵ The geographic discontinuity design is a special case of a regression discontinuity design (Lee and Lemieux, 2010), and has been previously applied, among others, in education economics (see, e.g., Black, 1999; Bayer et al., 2007; Lalive, 2008). See Keele and Titiunik (2015) for an overview of geographic discontinuity designs.

smoothly over space (e.g., distance to airports and consequently the availability of airline services) are controlled for and cannot cause a local difference in program activity.

We employ a dataset provided by an anonymous international frequent flier program with multiple European sponsoring airlines. Beyond the availability of geocoded membership and transaction data, there are several interesting aspects of these data that fit well with our research design. First, all sponsoring airlines represent the distinct national airline brand in their respective domestic countries. Second, the sponsoring airlines are active in the Schengen area/customs union of Europe. The open borders that exist in this area contribute to the plausibility of the geographic discontinuity design's key identifying assumption that unobserved supply and demand characteristics vary continuously through the border. Third, the micro level of the data enables us to provide a wider picture of how loyalty towards the sponsoring airlines changes at their national borders. Specifically, we decompose the overall program activity, as measured by the demand for mileage, into an *extensive margin*, i.e. the probability that consumers become member of the program, and an *intensive margin*, i.e. the frequency and size (in mileage) of flight activities by program members.

Our empirical analysis provides evidence of large brand loyalty advantages for national airlines in their domestic country. Just outside the national borders of the sponsoring airlines, semiannual mileage earned within the program drops by 11 miles per capita. This implies that the demand for mileage is nearly 60% lower among foreign consumers. On the extensive margin, we find that the program membership rate drops by 0.8% point at the border, which implies that foreign consumers are about 70% less likely to be a program member. Hence, the dramatic decrease in program activity is to a large extent driven by a lower number of program members.

On the intensive margin, discontinuities may either reflect changes in purchase behavior or in membership composition at the border. Ignoring differences in membership composition, we find no discontinuity in purchase frequency and a positive discontinuity of about 400 miles, or 40 per cent, in transaction size. Following the approach of Lee (2009) and Dong (2017) we correct for selection bias by deriving bounds on the intensive margin discontinuities among the subgroup of 'always participating' members (i.e., those who are member irrespective of being domestic or foreign). For purchase frequency, the lower bound indicates that foreign members may purchase up to about 3 flights *less* semi-annually than domestic members, while the upper bound rules out that foreign members purchase over 0.15 flight *more* than their domestic counterparts. For transaction size, the bounds range from 800 miles *less* to 400 miles *more* per flight for foreign members. Although we cannot statistically rule out that foreign members have a similar (or even higher) purchase frequency and transaction size, the evidence provided by these bounds, especially in terms of purchase frequency, is suggestive of foreign members purchasing less than domestic members, all else equal.

These novel findings contribute to the broad empirical literature on airline competition.⁶ To our knowledge, we are the first to carry out an empirical analysis of consumer loyalty towards national airlines. One context in which our findings can be illuminating is the ongoing market liberalization of international aviation. Despite the freedom to operate international routes between third countries as offered by the deregulation of Europe's skies almost 20 years ago, airlines are still predominantly operating routes connected to their domestic countries. For instance, within the European single market in 2016, only 15% of the departing flights was operated by third country carriers, of which the majority were low-cost carrier flights (OAG, 2017). Besides well-known supply-side explanations for this phenomenon (e.g., historical airport slot rights, ongoing bilateral regulation on extra-EU routes), our paper offers a demand-side perspective: airlines might have a hard time competing on foreign grounds where the loyalty of consumers favors local competitors.

2. Setting and data

2.1. Spatial setting

Our primary data is provided by a major international frequent flier program with multiple sponsoring airlines. The domestic countries of these sponsoring airlines are part of the Schengen area/customs union of Europe and share borders with a set of foreign countries that, except for one which we will exclude from the analysis, are also part of the Schengen area/customs union of Europe. Hence, the borders considered in this paper are completely open, characterized by free movement of people, goods, services and capital. We divide these borders into a total of 30 border regions (as detailed below). Each border region contains an area that belongs to the domestic country of one of the program's sponsoring airlines and an area that belongs to a neighboring foreign country that is not domestic to any of the sponsoring airlines. We analyze differences in program activity between domestic and foreign consumers that live within the same border region and in close proximity (on opposite sides) to the border.

The main analysis focuses on the average effect over all border regions, but it seems plausible that there is heterogeneity across border regions. For example, at some borders consumers on opposite sides use a common language, whereas at others language barriers exist. Moreover, most borders have no physical barriers, but there are mountain ranges at parts of some borders. As a sensitivity analysis, we analyze heterogeneity by considering border regions with such specific characteristics separately.

⁶ The difference in the number of studies between domestic versus international airline industries is noteworthy. This is presumably due to data availability reasons. One notable exception is the research on international airline alliances, which has received substantial academic attention (see, e.g., Brueckner and Whalen, 2000; Park and Zhang, 2000; Brueckner, 2001; 2003; Whalen, 2007; Bilotkach and Hüschelrath, 2013).

2.2. Data

The confidential data obtained from the frequent flier program comprises an approximately 7.5% random sample of the program members at the end of the second quarter of 2015. For each member, these data provide their age, gender and residential location, as well as information on their transactions within the program during the first two quarters of 2015. The number of flights made and mileage earned are the two main transaction variables. Within the program, a flight is defined as a single flight leg. Hence, a one-way direct trip counts as one flight, a one-way indirect trip counts as two flights, and so on. Mileage earned is not the actual flight mileage but a positive function of the flight distance and fare class of each flight (e.g., economy, business), where the flight distance gives the base level of miles and the fare class determines the accrual percentage.

To implement our geographic discontinuity design, we gather maps of all municipalities and national borders of the domestic and neighboring countries of the sponsoring airlines (Eurostat, 2017b). We use the members' residential location to match each member to a municipality and derive the number of nonmembers per municipality using the municipalities' population.

Next, we construct two key municipality-level spatial variables for all consumers (i.e., members and nonmembers) in our dataset. First, we calculate the municipality's distance to the border, defined by the Euclidean distance between the municipality's geographic midpoint and the nearest point on the border. Second, we match municipalities to border regions, by dividing all borders into segments of approximately 100km and assigning each municipality to one of these segments based on proximity.⁷ We also compute the municipality-level distance to the nearest hub of the sponsoring airlines and the nearest major airport where at least one of the sponsoring airlines is present, using a map of all European airports (Eurostat, 2017c) and airline frequency data (OAG, 2017).⁸ Finally, we augment the consumer observations with the degree of urbanization of their municipality (Eurostat, 2017a), and average income in their NUTS-3 region (GeoService RUG, 2017).⁹

The empirical analysis focuses on consumers that live within 75 km of the border, hence we drop all consumers that live farther away from the border. This results in a final dataset comprising 13,241 municipalities including 4,902,715 consumers, of which 32,858 are member and 4,869,857 are nonmember. Table 1 describes the relevant variables in this final dataset.

2.3. Descriptive statistics

Table 2 presents descriptive statistics. Within 75 km of the border, 61% of the consumers are foreign and 39% are domestic. The overall program membership rate is 0.7%.

⁷ We test the robustness of our results to an alternative border region specification in a sensitivity analysis.

⁸ Major airports are defined as the top-100 European airports by number of departing passengers in 2015.

⁹ The degree of urbanization is a classification of municipalities into cities, towns and suburbs, and rural areas.

Table 1
Description of variables.

Variable	Description
<i>Main variables</i>	
Foreign (0, 1)	Indicator for whether municipality n is foreign
Border distance	Distance between municipality n and the border
Border region	Border region of municipality n
Mileage	Mileage earned by consumer i in municipality n
Program membership (0, 1)	Indicator for program membership by consumer i in municipality n
Purchase frequency ^a	Number of flights of consumer i in municipality n
Transaction size ^b	Average mileage per flight of consumer i in municipality n
<i>Control variables</i>	
Airport distance	Distance between municipality n and nearest major airport
Hub distance	Distance between municipality n and nearest hub of sponsoring airlines
Degree of urbanization	Degree of urbanization of municipality n
Income (000s)	Average income (per capita) of municipality n (measured at the NUTS3 level)
Age ^a	Age of consumer i in municipality n
Male (0, 1) ^a	Indicator for whether consumer i in municipality n is female

Note(s): ^aOnly observed for members; ^bonly observed for members with nonzero purchase frequency.

Members make 1.6 flights in the semiannual sample period, each worth an average of about 1050 miles. The mileage earned is more than 4 times higher and program membership rate 7 times more likely on the domestic side of the border. Domestic and foreign members have an almost identical purchase frequency, while transaction size is considerably higher among foreign members. Foreign consumers live about 90km further away from the closest main hub of the sponsoring airlines, but about 23 km closer to other major airports. With respect to the remaining control variables there are no noteworthy differences.

3. Empirical setup

3.1. Decomposition and operationalization of the activity within the frequent flier program

We decompose the activity in the frequent flier program by using the extensive–intensive margin framework commonly employed in the economic literature. This decomposition framework allows us to provide a wider picture of the differences in frequent flier program activity between domestic and foreign consumers, by breaking down their overall level of activity into the likelihood that consumers become member of the program (i.e., *extensive margin*) and the intensity of their flight activities conditional on program membership (i.e., *intensive margin*).

Specifically, the overall level of program activity by consumer i in municipality n , denoted M_{in} and measured in terms of mileage earned, can be decomposed into an

Table 2
Descriptive statistics.

Variable	Full sample		Domestic consumers		Foreign consumers	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
<i>Main variables</i>						
Foreign (0, 1)	0.609	0.488				
Border distance	35.220	22.062	31.730	22.282	37.459	21.651
Mileage	12.117	542.882	23.419	760.925	4.867	335.919
Program membership (0, 1)	0.007	0.082	0.014	0.117	0.002	0.046
Purchase frequency ^a	1.612	4.079	1.612	4.230	1.615	3.365
Transaction size ^b	1063.496	1286.661	984.517	1194.214	1387.606	1570.669
<i>Control variables</i>						
Airport distance	71.466	46.311	85.942	49.380	62.179	41.714
Hub distance	267.852	192.867	224.811	204.882	295.464	179.622
Degree of urbanization	1.805	0.736	1.807	0.788	1.804	0.701
Income (000s)	32.389	10.948	30.536	7.183	33.578	12.662
Age ^a	44.673	16.743	44.887	17.126	43.770	14.988
Male (0, 1) ^a	0.598	0.490	0.583	0.493	0.658	0.474

Note(s): ^aonly observed for members; ^bonly observed for members with nonzero purchase frequency.

extensive margin and an intensive margin:

$$M_{in} = E_{in} \times I_{in}, \tag{1}$$

where E_{in} is the extensive margin which is operationalized by program membership, and I_{in} is the (total) intensive margin which can itself be decomposed into a *frequency intensive margin* and a *size intensive margin*:

$$I_{in} = I_{in}^f \times I_{in}^s, \tag{2}$$

where I_{in}^f is the frequency intensive margin which is operationalized by purchase frequency, and I_{in}^s is the size intensive margin which is operationalized by transaction size.

3.2. Geographic discontinuity design

To quantify the difference in program activity between domestic and foreign consumers, we estimate discontinuities at the national borders of the sponsoring airlines by a geographic discontinuity design (e.g., [Black, 1999](#); [Bayer et al., 2007](#); [Lalive, 2008](#); [Keele and Titiunik, 2015](#)). At the heart of our research design is the idea that at the national borders the composition of residents changes discretely from predominantly domestic to predominantly foreign.¹⁰ Under the condition that other factors that may impact

¹⁰ We are grateful to an anonymous referee for pointing out that our design is strictly speaking not a ‘sharp’ discontinuity design. That is, the probability of being foreign does not jump from 0 to 1 at the border but likely at a lower rate, due to a (small) fraction of domestic and foreign consumers living across the border.

program activity are continuous around the border, any discontinuous shift in program activity at the border can be attributed to the nationality of residents.

This approach addresses the fundamental issue that domestic and foreign consumers are not randomly distributed over space, and hence a naive comparison of their program activity yields biased estimates because of differences in local supply and demand characteristics. For example, the sponsoring airlines typically provide a more extensive range of products at their domestic airports (e.g., routes, frequencies) and therefore offer a more attractive program for domestic consumers who live closer to these airports (Lederman, 2007; 2008). Another potential source of bias is spatial variation in regional characteristics that affect demand for air travel. For example, a major business center may lead to higher local incomes leading to higher demand for personal travel or generate higher demand for business travel (e.g., Bel and Fageda, 2008; Brueckner et al., 2013). However, under the key identifying assumption that supply and demand characteristics vary continuously over space, and by conditioning on geographic location, our design obtains unbiased estimates of the differences in program activity between domestic and foreign consumers.¹¹

The plausibility of the key identifying assumption hinges on the openness of the borders that we study, which ensures that consumers that reside on opposite sides of the same border are part of the same market (e.g., the access time to airports are nearly identical) and therefore supply characteristics can be expected to be reasonably continuous around the border. Moreover, the open borders, and related opportunities for cross-border arbitrage (e.g., in the underlying labor and housing markets), should prevent strong discontinuities in demand characteristics (e.g., income). We provide diagnostic tests of the validity of our key identifying assumption by examining spatial variation in some important supply and demand characteristics around the border, and by analyzing the impact of including these characteristics as covariates in our models.

3.3. Addressing selection bias on the intensive margin

It is important to highlight that the geographic discontinuity design yields an unbiased estimate of the discontinuity on the extensive margin, but not in general on the intensive margin because the domestic consumers that become member are not necessarily the same type of consumers as the foreign consumers that become member. For example, it is likely that the reservation mileage for program membership differs between domestic and foreign consumers, with domestic consumers becoming member of the program at

This biases our discontinuity towards zero, because there might be program activity on the border's foreign side from domestic consumers that live abroad (and vice versa).

¹¹ In other words, by examining differences between consumers locally at the border, we resemble as close as possible a randomized experiment, in which the 'treated' (foreign) group does not differ on other factors determining program activity compared with the 'control' (domestic) group. A standard criticism of discontinuity designs is that individuals may behave strategically around the border. This, however, is unlikely to be a problem here, as it is highly implausible that consumers sort themselves in domestic or foreign municipalities *because* they prefer a certain airline brand.

lower levels of (expected) mileage with the sponsoring airlines. Hence, the geographic discontinuity design does not guarantee that domestic and foreign consumers are comparable *conditional on program membership* (Lee, 2009; Dong, 2017). As purchase frequency and transaction size are only observed for members, this causes problems for attributing a causal interpretation to the intensive margin discontinuities.

We address this selection bias by estimating lower and upper bounds on the intensive margin discontinuities in the spirit of Lee (2009) and, more recently in the context of discontinuity designs, Dong (2017). We make two assumptions that are commonly used to construct bounds in other studies (e.g., Lee, 2009; Chen and Flores, 2015; Dong, 2017) and are plausible in our context. First, we assume that foreign consumers are less likely to become member than domestic consumers (i.e., a monotonic selection assumption). This implies that *all* foreign members belong to a subgroup of so-called ‘always participating’ members, that is, members whose domestic counterparts are also participating in the program. On the other hand, domestic members belong either to this subgroup, or to a subgroup of ‘excess’ members, that is, members whose foreign counterparts are not participating in the program. Although we cannot observe which of the domestic members belong to this second subgroup, it is possible to estimate the proportion of ‘excess’ members and trim the upper and lower tail of the domestic intensive margin distributions to yield lower and upper bounds on the discontinuities for the subgroup of ‘always participating’ members.

To tighten the bounds, we furthermore assume that the ‘excess’ domestic members have a lower purchase frequency and transaction size *on average*, compared with the domestic ‘always participating’ members (i.e., a mean dominance assumption). This assumption is in line with a lower reservation mileage for program membership on the domestic side of the border inducing domestic consumers with lower levels of consumption to join the program. Given this assumption, the intensive margin distributions for ‘always participating’ domestic members have an expectation greater or equal than the mixture of the intensive margin distributions for ‘always participating’ and ‘excess’ domestic members. It follows that the discontinuities obtained using a standard design that ignores sample selection can be interpreted as the upper bound and one can apply the trimming procedure to identify the lower bound (Dong, 2017).

3.4. Estimation setup

In line with the econometric literature (e.g., Hahn et al., 2001; Imbens and Lemieux, 2008; Lee and Lemieux, 2010), we implement our geographic discontinuity design by estimating regression discontinuity models, with M_{in} , E_{in} , I_{in}^f , and I_{in}^s as the outcome variables, distance to the border, x_n , as the running variable, and the foreign indicator, f_n , as the treatment. We formulate the models for a generic outcome variable, Y_{in} , which represents any of the four aforementioned outcome variables.

The baseline econometric specification that we estimate is as follows:

$$Y_{in} = \tau f_n + \beta_1 x_n + \beta_2 f_n x_n + \phi_s + \alpha + \epsilon_{in}, \text{ with } |x_n| \leq h, \quad (3)$$

where f_n is a binary foreign indicator variable for municipality n ; x_n is the distance to the border of municipality n , which is negative for domestic municipalities and positive for foreign municipalities, so that we have $f_n = 1$ if $x_n > 0$ and $f_n = 0$ if $x_n < 0$; τ provides a point estimate of the discontinuity at the border; β_1 and β_2 represent the linear relationship between the outcome variable and distance to the border; ϕ_s are border region fixed effects capturing border region-invariant characteristics; α is an intercept; and ϵ_{in} is a random error term.¹²

We relax the linearity assumption between the outcome variable and distance to the border by using a local linear estimation approach.¹³ Specifically, we estimate Eq. (3) on the subset of consumers in municipalities within a certain bandwidth, denoted h , around the border, using a rectangular kernel. We use a bandwidth of 50 km as a baseline, and test the robustness of our estimates to different bandwidths by estimating Eq. (3) for a range of bandwidths.¹⁴

The specification in Eq. (3) resembles a standard regression discontinuity setup, except for the inclusion of the border region fixed effects. These fixed effects do not only improve efficiency, but are also needed for consistency. The border stretches out over more than 4,000 km, and program activity might vary substantially along the border. For instance, in some border regions program activity may be higher because of a nearby business center or major airport attracting residents with relatively high demand for air travel. As not every border region has an equal share of domestic and foreign consumers, this may imply a correlation between the foreign indicator and the error term. Another way to think about these fixed effects is that they ensure that we estimate differences between domestic and foreign consumers that live close to the *same* part of the border.

The border region fixed effects are coded using the weighted effects transformation by Sweeney and Ulveling (1972). This transformation differs from conventional dummy transformation by setting the impact of the reference region equal to the weighted negative sum of the coefficients for the other regions, instead of equal to zero.¹⁵ Although these two transformations are functionally equivalent, it ensures that the estimated intercept, α , is equal to the mean of the outcome variable conditional on that both f_n and x_n are equal to zero. In other words, α equals the mean of the outcome variable for the average domestic consumer at the border. For example, in the extensive margin model ($Y_{in} = E_{in}$), α represents the average program membership rate just at the domestic side

¹² Additional covariates can be straightforwardly included in this specification. Although their inclusion is not needed for consistency, they can be useful to test the validity of the discontinuity design (Lee and Lemieux, 2010). For this reason, we do include additional covariates in a sensitivity analysis.

¹³ Another approach to relax the linearity assumption is to use polynomial functions of x_n (Lee and Lemieux, 2010). We opt for the local estimation approach, as this generally leads to more robust estimates, better coverage of confidence intervals and avoids issues related to choosing the order of the polynomial (Gelman and Imbens, 2017).

¹⁴ We are aware of recent studies on statistically optimal bandwidths (see, e.g., Calonico et al., 2014). These bandwidths are optimal with respect to a specific model, which implies different bandwidths for different models (e.g., the optimal bandwidth for extensive margin model is not the same as the ones for the intensive margin models). To avoid this confusion, we opt for choosing a baseline bandwidth that is similar across all models, and show that our estimates are insensitive to the choice of bandwidth.

¹⁵ See also Nieuwenhuis et al. (2017) for the differences between dummy, effects and weighted effects coding.

of the border. This intercept can be used as a ‘domestic counterfactual’ against which the estimated discontinuity can be compared, allowing us to report an estimate of the relative size of the discontinuity, denoted ρ , by expressing τ as a share of the domestic counterfactual, α , as follows:

$$\rho = \tau / \alpha. \quad (4)$$

We now turn to estimating the bounds on the intensive margin discontinuities. Recall that we can interpret our point estimate of the discontinuity, τ in Eq. (3), as the upper bound, and apply the trimming procedure to estimate the lower bound. Following Lee (2009) and Dong (2017), our approach amounts to first estimating the fraction of ‘excess’ domestic members, next finding the corresponding quantile of the domestic intensive margin distributions which is used to trim the lower tail of these distributions, and then compute the lower bound by re-estimating the discontinuity using the trimmed distributions.

Let q be the fraction of ‘excess’ domestic members. This fraction is estimated by dividing the difference in the domestic and foreign membership rates at the border, by the domestic membership rate at the border (i.e., the relative discontinuity effect, ρ , on the extensive margin). Next, we estimate a quantile regression for the q th quantile of the outcome distribution, as follows:

$$Q_q(Y_{in}) = \tau^q f_n + \beta_1^q x_n + \beta_2^q f_n x_n + \phi_s^q + \alpha^q + \epsilon_{in}^q, \text{ with } |x_n| \leq h, \quad (5)$$

which is the quantile regression equivalent of Eq. (3).¹⁶ The parameter α^q provides an estimate of the q th quantile of the intensive margin distributions for domestic consumers at the border.

We trim the intensive margin distributions on the domestic side of the border by dropping all domestic members who have a purchase frequency or transaction size less than or equal to the estimated quantile, α^q . Finally, we re-estimate Eq. (3) using this trimmed sample to arrive at the lower bound on the discontinuity.

4. Empirical results

4.1. Graphical evidence and diagnostic tests

We first provide graphical support for the presence of discontinuities in program activity at the national borders of the program’s sponsoring airlines by presenting various plots showing the spatial variation in the outcome variables around the border. Moreover, we test our key identifying assumption by providing similar plots that show the absence of discontinuities in demand and supply characteristics around the border. We also provide evidence of differential selection into program membership at opposite sides of the border. All plots throughout this section are constructed by regressing the variable in

¹⁶ For purchase frequency, we use the smoothing procedure described in Machado and Silva (2005), as it is a count variable, so standard quantile regression does not apply.

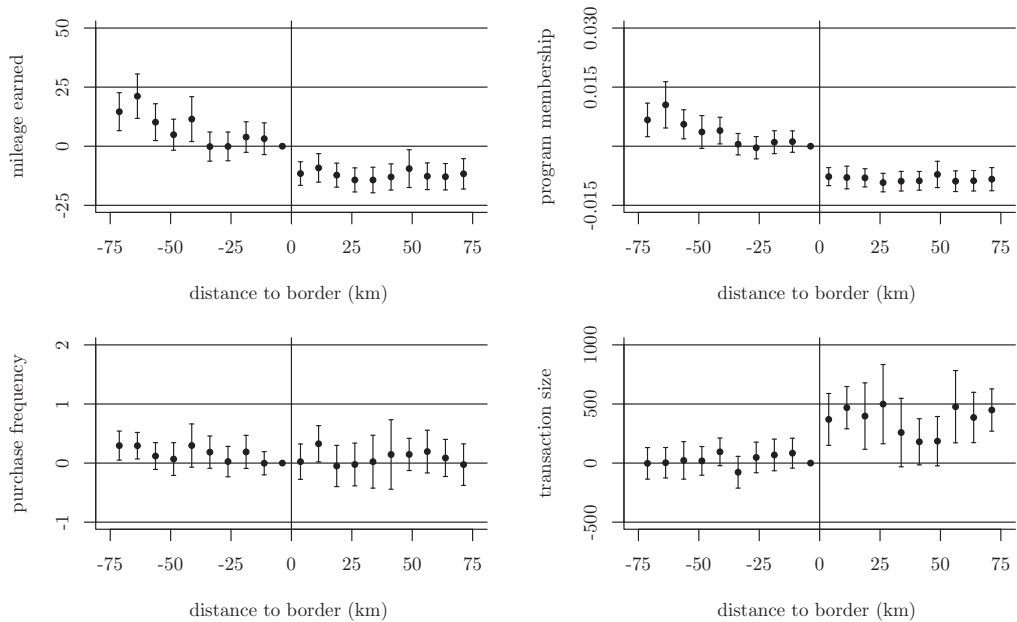


Fig. 1. Relationships between outcome variables and distance to the border.

question on the border region fixed effects and a series of distance to the border dummies, and plotting the estimated coefficients on these distance dummies. The dummy just on the domestic side of the border normalized to zero (see [Bayer et al., 2007](#), for a similar presentation).

[Fig. 1](#) shows the plots for the four outcome variables. Three main patterns emerge from these plots. First, as shown in the top-left panel, there is a clear drop in the overall level of program activity at the border, while similar discontinuities are not present at non-border points. Thus, foreign consumers that live just across the border earn a considerably lower level of mileage in the frequent flier program compared with their direct domestic neighbors. Second, as shown in the top-right panel, it appears that the drop in overall program activity is driven to a considerable extent by the extensive margin. That is, the overall level of program activity is considerably lower on the foreign side of the border because less consumers become member of the program. Third, regarding the intensive margins, as shown in the lower panels, there is no discontinuity in purchase frequency, but a discontinuous jump at the border in transaction size. This suggests that although foreign consumers are less likely to be program members, those that select themselves into membership accrue more mileage by spending more per flight.

Similar plots for two important supply and two important demand characteristics are shown in [Fig. 2](#). These plots show that all four variables are reasonably continuous through the border. In particular the spatial variation in distances to airports, as shown in the top panels, is clearly continuous. At the same time, there are no visible discontinuities

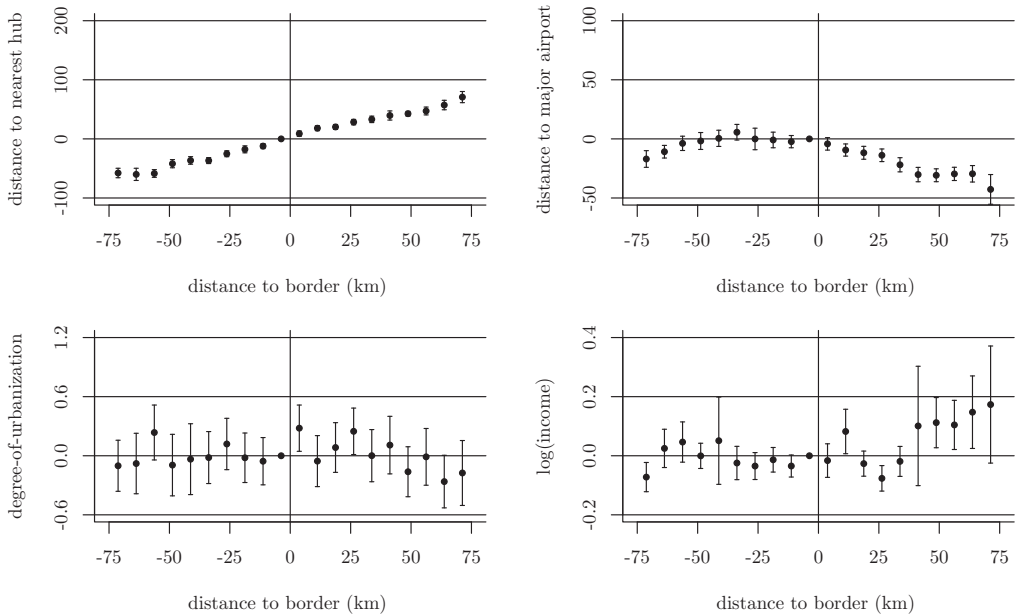


Fig. 2. Relationships between market and regional characteristics and distance to the border.

at the border in terms of income and degree of urbanization although the patterns are somewhat less smooth.¹⁷

Finally, Fig. 3 shows the spatial variation in the members' gender and age.¹⁸ It is important to stress that these two characteristics are only observed for members and, hence, these plots are conditional on program membership. The plots are indicative of differential selection into program membership at each side of the border. Overall, foreign members are more likely to be male and belong to the working population, and less likely to be retired. This implies that for estimating discontinuities on the intensive margin, the discussed sample selection corrections are warranted.

4.2. Baseline model estimation results

Table 3 reports the estimates of the discontinuities at the border. Each row provides the estimates for a different outcome variable. The first column provides the number of observations. Point estimates and corresponding standard errors of the domestic counterfactual, α , and the discontinuity, τ , as obtained from Eq. (3), are given in the second and third columns. Below the discontinuity estimates, we also present the relative discontinuity effect, ρ , as obtained from Eq. (4) and converted to percentages. The final

¹⁷ We should also note here that degree of urbanization is a categorical variable with three levels (i.e., cities, towns, and rural areas), and therefore strictly one should make separate plots for the density of each level. These plots are presented in Appendix A, and show that there is a small discontinuous drop in the number of cities and a jump in the number of towns at the border.

¹⁸ The age groups are defined according to the standard used by Eurostat.

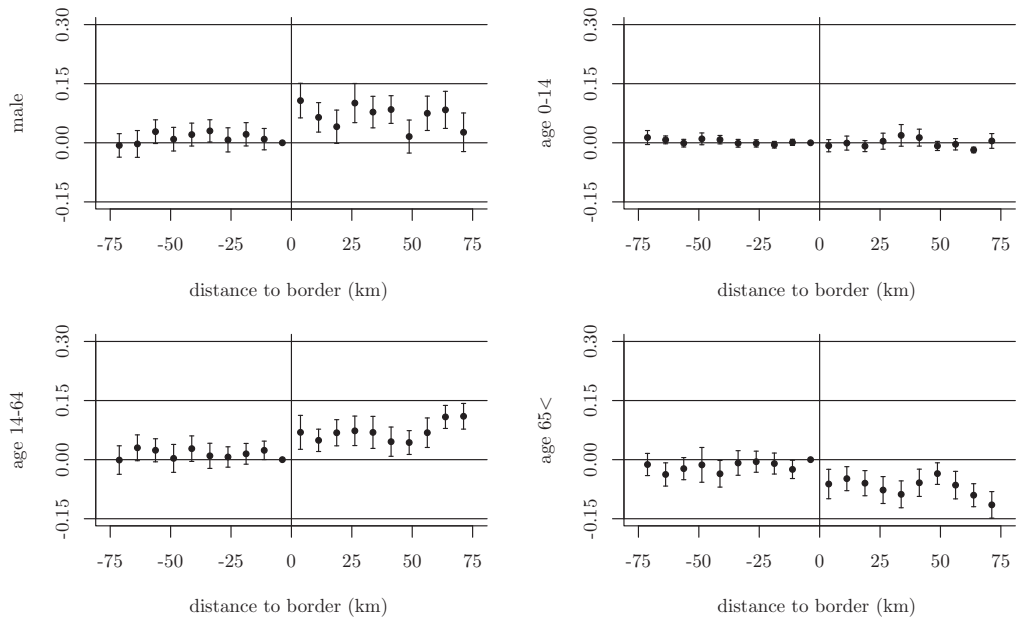


Fig. 3. Relationships between member characteristics and distance to the border.

Table 3
Baseline model estimation results.

				Bounds on discontinuity effect		
Outcome variable	Obs.	Domestic counterfactual	Discontinuity effect	Lower bound	Upper bound	95% CI
<i>Program activity</i>						
Mileage	29,542	19.893** (1.964)	−11.370** (2.503) −57.2%			
<i>Extensive margin</i>						
Program membership	29,542	0.011** (0.001)	−0.008** (0.001) −68.9%			
<i>Intensive margin</i>						
Purchase frequency	20,703	1.532** (0.065)	0.152 (0.140) 9.9%	−3.223** (1.061) −64.8% ^a	0.152 (0.144) 9.9%	[−4.968 0.389]
Transaction size	7,489	1,019.3** (38.0)	411.6** (85.2) 40.4%	−821.5** (244.4) −35.6% ^a	411.6** (87.6) 40.4%	[−1,223.5 555.7]

Note(s): Estimation follows Section 3.4, using a bandwidth of 50 km and a rectangular kernel. Border region fixed effects and distance to the border are not reported. ^aTrimming the domestic distributions also changes the domestic counterfactual that is used to compute the relative discontinuity effect, which is 4.971 for purchase frequency and 2,308.923 for transaction size. * $p < 0.05$; ** $p < 0.01$.

three columns are reserved for the bounds on the intensive margin discontinuities and the corresponding confidence intervals. As the running variable (distance to the border) and treatment (foreign indicator) are on the municipality level, the standard errors have been clustered at the municipality level. Standard errors on the bounds are obtained by bootstrapping, using 1,000 nonparametric bootstrap samples. The reported confidence intervals are of the type discussed in [Imbens and Manski \(2004\)](#), which provide the confidence interval for the true discontinuity instead of for the estimated interval.

The estimate of the discontinuity in mileage is equal to -11.370 , which implies that foreign consumers at the border earn just over 11 miles less than their direct domestic neighbors. In light of the domestic counterfactual, which shows that the average mileage earned just at the domestic side of the border is equal to 19.893, this amounts to a mileage drop of nearly 60% (57.2%). On the extensive margin, the estimate of the discontinuity in the program membership equals -0.008 . This implies that, at the border, the foreign membership rate is 0.8 per cent points lower compared with the domestic membership rate. Given the domestic counterfactual membership rate of 0.011, this implies a decrease in program membership of almost 70% (68.9%). When not controlling for differences in membership composition due to self-selection, the findings on the intensive margin are as follows. For purchase frequency, the discontinuity is not statistically significant at conventional significance levels. For transaction size it equals 411.602, implying that members just on the foreign side of the border earn approximately 400 miles more per flight than their domestic counterparts. This discontinuity in transaction size represents a 40% (40.4%) increase over the domestic counterfactual transaction size of 1,015.426 miles per flight.

The estimated bounds on the intensive margin discontinuities provide an insight into the differences between ‘always participating’ domestic and foreign members. For purchase frequency, the estimated lower and upper bounds are -3.223 and 0.152 , respectively, while the bounds for transaction size are -821.512 and 411.602 . The width of these bounds is quite substantial and the corresponding confidence intervals include zero. Hence, we cannot *statistically* infer whether the ‘always participating’ foreign members spend more or less than their domestic counterparts. Nevertheless, the bounds are still informative on the size of their differences. The upper bound on purchase frequency is not statistically significant at conventional significance levels and equals only 0.15 flight. So, we can rule out that foreign members purchase significantly more flights than domestic members. In contrast, the lower bound of almost 3 flights less for foreign members is both statistically and economically significant. These bounds are therefore suggestive of a higher purchase frequency on the domestic side of the border. The bounds on transaction size are less informative, but because the negative region covered by the bounds is still twice as large as the positive region, it is again more likely that the effect is negative.

In addition, we like to point out that it is plausible that the ‘excess’ domestic members are relatively dominant in the lower tail of the intensive margin distributions. Even under the mean dominance assumption, the upper bounds are based on the rather conservative assumption that the average purchase frequency and transaction size of ‘excess’ domestic

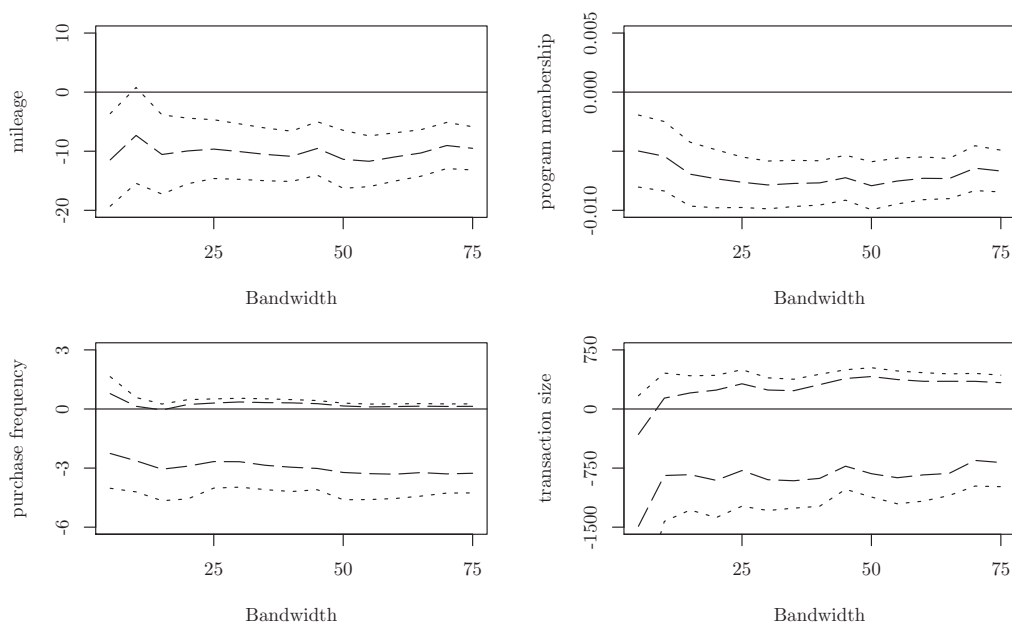


Fig. 4. Bandwidth plots for discontinuity effects.

members is equal to the corresponding averages of the ‘always participating’ domestic members. Given that benefits of the program are proportional to the amount of mileage it is more likely that the ‘excess’ members have a lower purchase frequency and transaction size on average. In conclusion, the evidence provided by the bounds points towards the presence of negative discontinuities on the intensive margin. That is, all else equal, foreign members likely have a lower purchase frequency and transaction size.

4.3. Sensitivity analyses

To verify the robustness of our estimates, we conduct a number of sensitivity analyses. The estimates appear robust to a range of bandwidths, alternative specifications, and various subsets of the data.

Fig. 4 illustrates the sensitivity of our estimates to bandwidth selection. For a range of bandwidths, we show the estimate of the discontinuity in overall program activity and extensive margin (top panels) and lower and upper bounds of the discontinuity in the intensive margins (lower panels) along with the associated 95% interval. All plots show robust patterns, indicating that our estimates are rather insensitive to choice of bandwidth.¹⁹

Table 4
Sensitivity analyses estimation results (overall program activity and extensive margin).

	Alternative specification			Border region subset ^a		
	Covariate-adjusted	Non-parametric	Alt. border regions	International services only ^a	Common language ^a	Mountain ranges ^a
<i>Program activity</i>						
Mileage	−10.063** (2.158) −44%	−13.762** (1.258) −60.6%	−11.267** (2.682) −60.8%	−11.123** (2.765) −70.8%	−15.175** (3.914) −78.7%	−4.977 (8.821) −53.2%
<i>Extensive margin</i>						
Program membership	−0.007** (0.001) −62.6%	−0.009** (0.001) −71.3%	−0.008** (0.001) −72.5%	−0.008** (0.001) −79.1%	−0.009** (0.001) −80.3%	−0.010** (0.002) −77.6%

Note(s): Estimation of variations on Eq. (3), using a bandwidth of 50 km and a rectangular kernel. Border region fixed effects and distance to border are not reported.

^a The number of observations in these subsets are 12,109, 10,887 and 7,433, respectively, in both the mileage and program membership models. * $p < 0.05$; ** $p < 0.01$.

Tables 4 and 5 report the estimates obtained from various sensitivity analyses. The first column in both tables provide the estimates for a specification including covariates.²⁰ The reported estimates for the discontinuities and the bounds on the intensive margin are largely similar to the baseline estimates. These results therefore add confidence in the ability of our geographic discontinuity design to effectively control for unobserved market and regional characteristics.

The second column shows estimates of a nonparametric specification that does not control for distance to the border. Although the differences between the nonparametric and baseline estimates are small, the discontinuity effects increase in magnitude and the lower and upper bounds are now more negative. This is in line with the idea that the nonparametric specification does not adequately control for the fact that domestic consumers are substantially closer to the hubs of the sponsoring airlines which potentially leads to an overestimate of the true discontinuity effects.

In the third column, we create alternative border regions based on each distinct border between a domestic and a neighboring foreign country and refit the models using these new border regions as fixed effects. The estimates reported in the third column are almost identical to the baseline estimates, suggesting that they are not sensitive to the specification of border regions.

In column four, we test whether a predisposition of domestic consumers towards domestic air travel can explain the discontinuity effects. We exploit the fact that in one of the domestic countries domestic air travel is practically nonexistent. Reassuringly, the

¹⁹ For small bandwidths (i.e., <10 km) the estimates become somewhat unstable, due to the limited number of remaining observations.

²⁰ These covariates are distance to the nearest major airport, distance to the nearest hub of the sponsoring airlines, income, degree of urbanization, gender and age. As the latter two variables are only observed for members, they are only included in the intensive margin models. The coefficient estimates of the covariates are available upon request.

Table 5
Sensitivity analyses estimation results (intensive margins).

	<i>Alternative specification</i>						<i>Border region subset^a</i>					
	Covariate-adjusted		Non-parametric		Alt. border regions		International services only		Common language		Mountain ranges	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
<i>Intensive margin</i>												
Purchase frequency	−3.212** (0.528)	0.065 (0.115)	−5.771** (1.222)	0.052 (0.065)	−5.266** (1.099)	0.149 (0.115)	−3.934** (1.272)	0.407** (0.134)	−5.194* (2.508)	0.146 (0.149)	−7.140** (2.508)	−0.719** (0.149)
	−60.1%	4.0%	−75.3%	3.1%	−75.2%	9.7%	−72.0%	38.7%	−78.6%	11.2%	−83.4%	−36.1%
Transaction size	−969.4** (257.0)	339.4** (85.8)	−946.4** (176.7)	319.8** (49.7)	−919.7** (211.2)	414.5** (83.0)	−1,850.8* (735.4)	306.8** (116.8)	−1,784.7 (1,032.0)	411.9** (134.7)	−160.3 (957.4)	607.7** (136.1)
	−35.4%	26.8%	−40.7%	32.3%	−38.4%	40.5%	−53.0%	23.4%	−52.1%	33.0%	−13.5%	128%

Note(s): Estimation of variations on Eq. (3), using a bandwidth of 50 km and a rectangular kernel. Border region fixed effects and distance to border are not reported.

^a The number of observations in these subsets are 11,232, 8,217, and 4,333, respectively, in the purchase frequency models and 3,962, 2,871, and 1,735, respectively, in the transaction size models. * $p < 0.05$; ** $p < 0.01$.

discontinuity effects remain largely similar when estimating the models on the subset of border regions of this domestic country.

In the remaining two columns we estimate the discontinuities for subsets of regions with a common language and border regions with mountain ranges. Because of the smaller samples used, standard errors increase substantially, especially for the intensive margin estimates. Moreover, it is likely that these regions do not only differ in terms of language or geographical barriers but also on other (unobserved) characteristics. This might explain the somewhat surprising finding of seemingly more pronounced discontinuities in common language regions, or the higher transaction sizes on the foreign side of mountain borders. Most importantly, however, the findings are qualitatively in line with our main findings and suggest that negative discontinuities in program activity persist in border regions with a common language or mountain ranges.

5. Conclusion

The importance of brand loyalty for understanding firm competition and market structure is widely recognized. Brand loyalty is thought to provide firms with a competitive advantage and may even deter entry. In global industries, such as the international airline industry, national brands may enjoy substantially higher levels of loyalty in their domestic country. It is difficult to estimate these loyalty advantages because of the combination of spatial differences in supply and demand characteristics and domestic and foreign consumers not being randomly distributed over space.

This paper examines the prevalence of national brand loyalty advantage in the airline industry, using geocoded microdata on program membership and transactions from a major international frequent flier program. These data allow us to address the endogeneity problems by estimating discontinuities in frequent flier program activity, in terms of mileage earned, at the national borders of the program's sponsoring airlines. Given the detailed level of the data we are furthermore able to isolate the extensive margin (i.e., membership) and intensive margins (i.e., purchase frequency and transaction size) of the overall program activity.

We demonstrate that foreign consumers earn about 60% less mileage than domestic consumers. This dramatic decrease in program activity is strongly driven by the extensive margin, with the program membership rate dropping by nearly 70%. Conditional on program membership but not controlling for self-selection, foreign consumers have a higher purchase frequency and transaction size, but this is likely because the group of foreign members differs from the group of domestic members. We control for this selection bias, by estimating lower and upper bounds on the intensive margin effects for a subgroup of members that participate in the program irrespective of being domestic or foreign. These bounds are suggestive of foreign members, all else equal, having a lower purchase frequency and transaction size.

These findings are in line with substantial brand loyalty advantages of national airlines in their domestic countries. Given that our research design rules out a number of

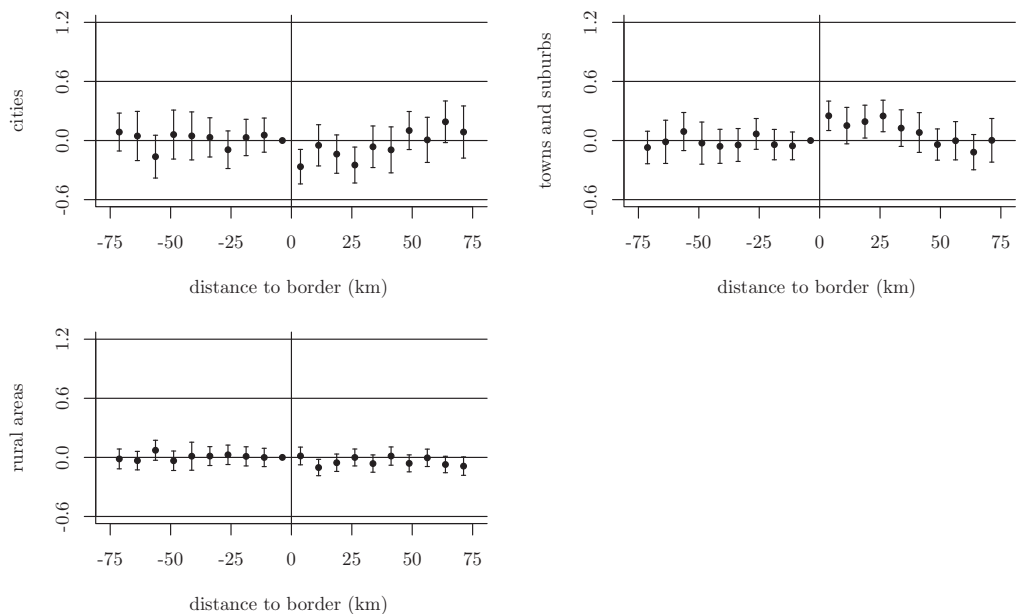


Fig. A1. Relationships between degree of urbanization and distance to the border.

alternative explanations, the results are consistent with the idea, well documented in the behavioral literature, that consumers are biased towards their own national brand. This national brand loyalty advantage seems to persist even after substantial liberalization of international aviation, and conceivably is one of the factors that hampers further integration of liberalized international airline markets.

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Appendix A. Additional diagnostic test degree of urbanization

Fig. A1.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.ijindorg.2018.02.005](https://doi.org/10.1016/j.ijindorg.2018.02.005).

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